RPC Semantics

Doug Woos

Logistics notes

Tom’s OH canceled this week

Last time

- Go tips and tricks
- RPC intro, using RPCs in Go
- MapReduce discussion

Outline

RPC semantics in detail

Go’s RPC semantics

RPC Warmup

What's the equivalent of:

- Procedure name?
- Calling convention?
- Return value?
- Return address?

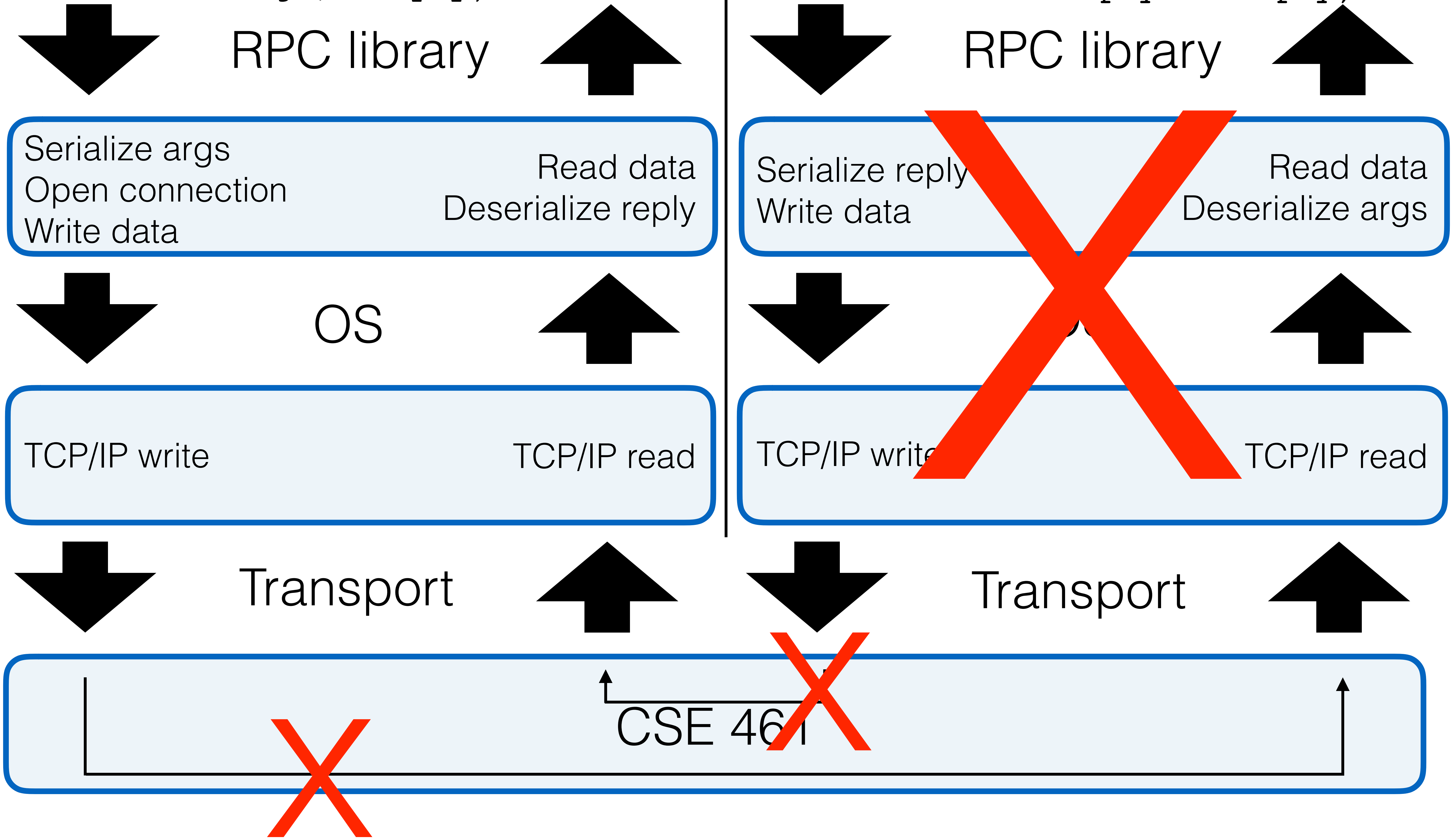
Semantics

semantics: meaning

RPC implementation

```
ok := call(address, "Worker.DoJob",
           args, &reply)
```

```
func (wk *Worker)
     DoJob(args *DJArgs,
           reply *DJReply)
```



Semantics

semantics: meaning

- ok == true: ???
- ok == false: ???
- Possibilities?

Semantics

At least once (NFS, DNS, …):

- true = executed at least once
- false = maybe executed, multiple times

At most once (Go, …):

- true = executed exactly once
- false = maybe executed once

- Exactly once (Lab 2 writes)
  - true = executed exactly once
  - never returns false

At least once

RPC library sends, waits for response

If none arrives, re-send request

After a few retries, give up and return an error

How should applications deal with this?

Example: one-node KV store (Redis)

Client sends PUT k v

Server gets request, reply dropped

Client sends PUT k v again

- What should the server do?

What if instead, op is “deduct $10 from bank acct”

What about TCP?

"Just use TCP"

TCP: reliable byte stream between two endpoints

- Retransmission of dropped packets
- Duplicate detection & removal

What if TCP times out and reconnects?

- User browses to Amazon
- RPC to purchase book
- Wifi spotty during RPC
- Browser reconnects

When does at-least-once work?

No side effects (e.g. MapReduce jobs)

- read-only, idempotent

NFS: readFileBlock, writeFileBlock

Application-level duplicate detection

At most once

Client includes unique id (UID) with each request

- same UID on re-send

RPC lib on server detects duplicates

```
if seen[uid] {
  return old[uid]
} else {
  r = Handler()
  old[uid] = r
  seen[uid] = true
  return r
}
```

Some at-most-once issues

How to ensure unique UID?

- large random numbers
- combine UID (e.g. MAC address) w/ sequence #

Can clients use same UID if they crash?

Get UID from server?

When can server discard `old`?

Option 1

- Never!

Option 2

- Unique client IDs
- per-client sequence number
- client includes “discard <= i” w/ all RPCs

Option 3

- only allow one outstanding RPC per client
- When seq+1 arrives, discard <= seq

Option 4

- Client gives up after n minutes
- Server discards after n minutes

Handling server crashes

Server will lose **`old`** on crash

- Does it need to be persisted?
- Does it need to be replicated?

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Needs to have same persistence/replication as data

Go RPC revisited

What are the semantics?

Go RPC revisited

At most once

Rely on TCP retry

- Open connection
- Write data
- TCP may retransmit

Return error if no reply after timeout

Go’s at-most once is not enough

Imagine side-effectful MapReduce

Master sends RPC to worker, gets a timeout

What does application do?

- Attempt to figure out if work was done
- Implement better at-most-once
- Lab 2!

Exactly once

Keep retrying forever

Need to survive client and server crashes

- Client must store pending RPCs on disk
- Server must store completed RPCs on disk

Takeaways

Failure makes RPCs complicated

Think carefully about semantics

Mechanisms in app vs. RPC vs. transport